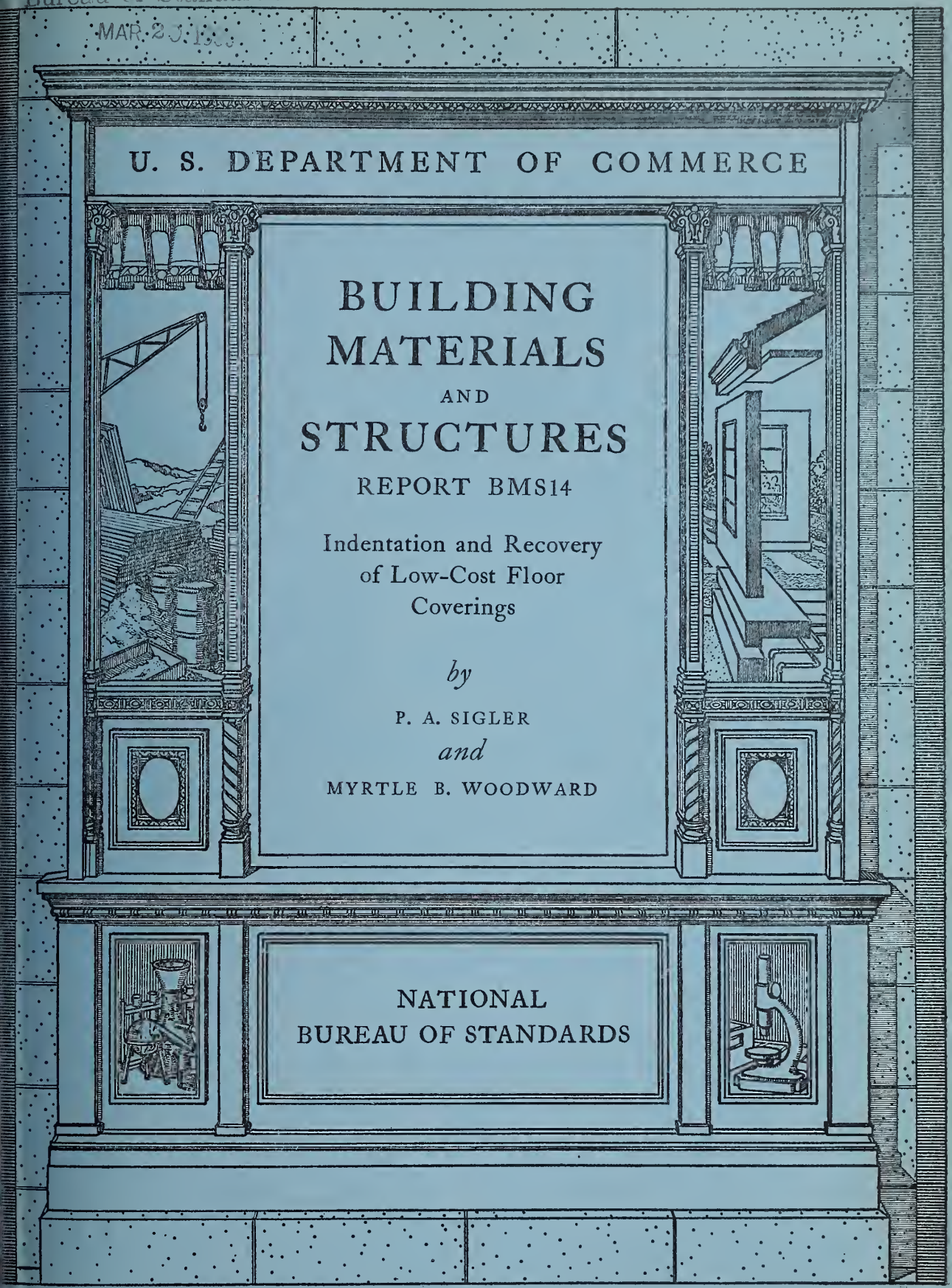

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BUILDING MATERIALS *and* STRUCTURES

REPORT BMS14

Indentation and Recovery of Low-Cost Floor Coverings

by

P. A. SIGLER *and* MYRTLE B. WOODWARD

ISSUED MARCH 7, 1939

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Foreword

In connection with the research program on building materials suitable for low-cost house construction being conducted by the National Bureau of Standards, tests have been made on various types of floor coverings in order to determine their relative performance with regard to indentation characteristics when in an atmosphere of 65-percent relative humidity and at a temperature of 72° F. This report presents in graphic form the results of indentation and recovery determinations on such floor coverings as asphalt tile, pressed fiber board, linoleum, felt base, rubber, and wood. For the benefit of the consumer, the results have been summarized in a chart showing the relative value of the various floor coverings with respect to comfort in walking in comparison with the extent to which they are permanently indented under abuse.

This work constitutes one phase of the investigation being made of important properties of floor coverings.

Lyman J. Briggs, *Director.*

Indentation and Recovery of Low-Cost Floor Coverings

by P. A. SIGLER *and* MYRTLE B. WOODWARD

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ABSTRACT

Indentation and recovery determinations for loads ranging from 25 pounds to 200 pounds on a flat-ended pin ¼ inch in diameter were made on 23 floor coverings at a relative humidity of 65 percent and temperature of 72° F. Indentation readings were taken for each load at intervals of time up to 30 minutes and then recovery readings at intervals of time up to 120 minutes. Various types of floor coverings were tested, such as asphalt tile, pressed fiber board, linoleums, felt-base floor coverings having various wearing surfaces, rubber, and wood. A description of the apparatus and the procedure used are given. The results are presented in graphic form to show the relative merits of the various floor coverings with respect to initial and 30-minute indentation under various loads and the recovery after removal of the load.

I. INTRODUCTION

The ability of a floor covering to depress readily under foot is a desirable property from the standpoint of personal comfort in walking. However, unless this property is coupled with an ability to recover to approximately normal shape upon removal of temporary loads, the floor covering will soon present an irregular and unsightly surface. The floor covering will gradually lose its comfort value and present a surface difficult to clean. Because the load applied in some locations is likely to be severe and prolonged, the ability of a floor covering to recover its shape after application of load is of additional importance. The severity of the loads applied by furniture can be reduced by the use of ample-sized and properly maintained casters or shoes.

Although there are indentation requirements in most of the Federal specifications for floor coverings,[1] the methods employed in testing the various types are quite varied with regard to time, load, and indenting tool. Each specification deals with the quality of a particular type of floor covering, not with the relative qualities or outstanding features of the various types. Comparable information on the several types is of direct interest to the consumer in selecting a floor covering to meet his particular

[1] The following Federal specifications for floor coverings may be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. at 5 cents each:

Title	Symbol
Linoleum; battleship	LLL-L-351
Linoleum; plain, inlaid and printed	LLL-L-361
Tile; asphalt	SS-T-306
Floor-coverings; rubber sheet	ZZ-F-461
Matting; rubber	ZZ-M-71
Tile; cork	LLL-T-431
Carpet; cork	LLL-C-96
Carpets and rugs; axminster	DDD-C-51
Carpets and rugs; velvet, plain	DDD-C-61a
Carpets and rugs; wilton	DDD-C-71a
Rugs; American-Oriental (washed)	DDD-R-751

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need. In view of the lack of comparable test data and the importance of a consideration of recovery or conversely residual identation along with indentation under load, indentation and recovery determinations were made on various types of floor coverings which might be suitable for low-cost house construction.[2] [3] By these determinations an effort is made to show the relative merits of the various floor coverings with respect to initial and 30-minute indentation under various loads and the recovery after removal of the load, when in an atmosphere of 65-percent relative humidity and at a temperature of 72° F.

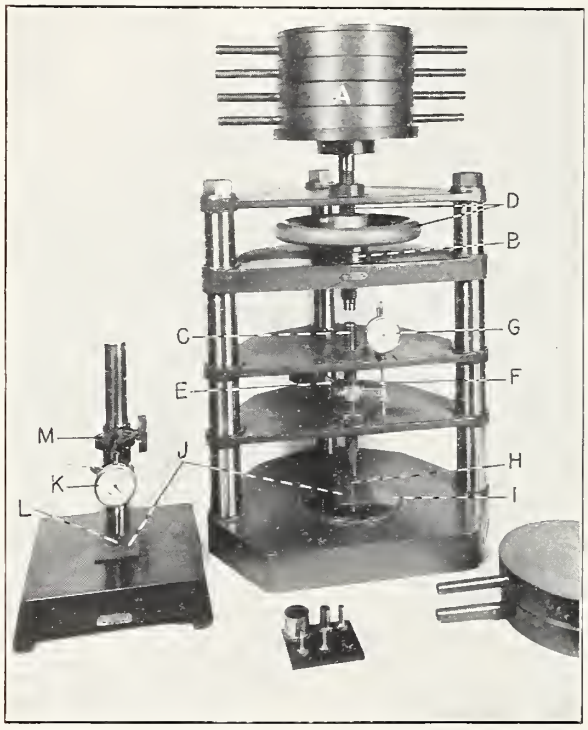

FIGURE 1.—*Indentation tester (at right) and thickness gage (at left).*

II. TESTING EQUIPMENT

Figure 1 shows the indentation tester (at the right) and thickness gage (at the left) used in these determinations. The indenting load (*A*) is transferred from a ball-bearing support (*B*) to the indenting plunger (*C*) by means of a screw and handwheel (*D*). Attached to the indenting plunger, which runs through two bearings, is a lever mechanism (*E*) which is used to counterbalance the weight of the plunger. Also attached to the plunger is an adjustable stop (*F*) which contacts the spindle of a dial micrometer (*G*) attached to the frame of the machine. The dial micrometer is graduated in thousandths of an inch and registers any movement of the plunger. The indenting tool (*H*), consisting of a flat-ended cylindrical steel rod ¼ inch in diameter, is attached to the lower end of the indenting plunger. The dial micrometer was adjusted to zero with the indenting tool in contact with the base plate (*I*) at a pressure of 20 lb/in.², so that the dial micrometer registered the thickness of a specimen (*J*) during indentation under load.

The thickness gage used to measure the original thickness of a specimen (*J*) as well as the thickness during recovery is shown at the left in figure 1. The dial gage (*K*) is graduated in thousandths of an inch and is equipped with a flat-ended foot (*L*), ⅛ in. in diameter, which exerts a pressure of 20 lb/in.² by means of a ¼-lb weight (*M*) on the top of the spindle.

III. TEST PROCEDURE

The specimens, consisting of 2-in. squares, were first conditioned in an atmosphere of 65-percent relative humidity and at a temperature of 72° F for at least 48 hours. The thickness of each specimen was measured at a marked location in the central portion with the thickness gage.

Precaution was taken to see that the bottom edges of the specimens were beveled smooth and that the specimens rested flat on the base plate of the gage. Most of the specimens had some tendency to either buckle or curl. Finger pressure was used to flatten the specimens. A dead weight of 1 kg was found to be insufficient to assure a flat contact.

The specimen was then placed under the indenting tool and the load applied. Time was

[2] H. L. Dryden, Research on Building Materials and Structures for Low-Cost Housing, NBS Rep. BMS1, (1938). Price 10c.

[3] Investigation of Low-Cost Floor Coverings, Letter Circular LC502F. May be obtained free from the National Bureau of Standards, Washington, D. C.

recorded from the instant the full load rested on the specimen; this could be readily determined from the movement of the hand on the dial micrometer. The dial micrometer was read at intervals for a total of 30 minutes. The load was removed at the end of 30 minutes and the thickness of the indented portion measured with the thickness gage at intervals up to a total of 120 minutes.

Indentation and recovery determinations were made on each floor covering for indenting loads of 25, 50, 100, 150, and 200 lb, which represent average pressures of 509, 1,018, 2,038, 3,058, and 4,075 lb/in.^{2}, respectively. Three specimens of each floor covering were tested at each indenting load. The agreement between the results obtained on individual specimens was good for most of the floor coverings.

IV. DESCRIPTION OF FLOOR COVERINGS

Indentation and recovery determinations were made on 23 samples of floor coverings, including several asphalt tiles; pressed fiber board; various linoleums such as battleship, inlaid, jaspe, and printed; felt-base floor coverings having various wearing surfaces, such as enamel, linoleum composition, asphalt mastic, and other compositions; rubber flooring in both sheet and tile form; and several wood floors. The floor coverings are listed in table 1 with brief descriptions. The sample numbers in table 1 correspond with the figure numbers of the graphs showing the results.

TABLE 1.—*Floor coverings tested*

Sample number	Average thickness [1]	Floor covering	Description [2]
	Inches		
2	0.127	Battleship linoleum	Plain pattern, brown.
3	127	do	Plain pattern, gray.
4	.129	do	Plain pattern, green.
5	.129	Marbleized linoleum	Marbleized pattern, green, mottled.
6	.077	Inlaid linoleum	Molded pattern, gray, mottled.
7	.096	Jaspe linoleum	Jaspe pattern, brown, streaked.
8	.076	Printed linoleum	Block pattern, brown. Wearing surface, enamel.
9	.081	Inlaid felt base	Straight-line pattern, cream, mottled. Wearing surface, linoleum composition.
10	0.074	Printed felt base	Flowered pattern, brown. Wearing surface, enamel.
11	.069	do	Block pattern, lavender. Wearing surface, enamel.
12	.090	Mastic felt base	Plain pattern, maroon. Wearing surface, asphalt mastic composition.
13	.077	Composition felt base	Jaspe pattern, brown, streaked. Wearing surface, nitrocellulose mastic composition.
14	.080	do	Mottled pattern, tan, mottled. Wearing surface, nitrocellulose mastic composition.
15	.128	Asphalt tile	Marbleized pattern, white, mottled. 1-minute indentation —0.007 in.[3]
16	.135	do	Plain pattern, black. 1-minute indentation —0.012 in.[3]
17	.125	do	Plain pattern, maroon. 1-minute indentation —0.012 in.[3] (so-called "economy tile")
18	.127	Sheet rubber	Marbleized pattern, brown, mottled. Cloth backing.
19	.123	Rubber tile	Marbleized pattern, gray, mottled. No backing.
20	.145	Pressed fiber board	Plain pattern, brown. Density 67 lb/cu ft.[4]
21	.789	Strip yellow pine	Flat grain, hollow back. Density 44 lb/cu ft.[4]
22	.776	Strip Douglas fir	Edge grain, flat back. Density 36 lb/cu ft.[4]
23	.783	Strip white oak	Flat grain, flat back. Density 40 lb/cu ft.[4]
24	.796	Short strip maple	Flat grain, flat back, equal length shorts. Density 47 lb/cu ft.[4]

[1] From original thickness measurements; ⅛-in. foot; 20 lb/in.^{2} pressure
[2] Color listed is the predominating color.
[3] Method prescribed in Federal Specification SS-T-306, "Tile; Asphalt."
[4] At 65-percent relative humidity and 72° F.

V. RESULTS

The results of the indentation and recovery determinations on the 23 floor coverings are shown graphically in figures 2 to 24, inclusive. The solid-line curves at the left of each figure show the indentation with respect to time caused by the ¼-in. flat-ended indenting tool for loads of 25, 50, 100, 150, and 200 lb. The solid-line curves at the right show the residual indentation with respect to time after removal of the loads. The broken lines connect the corresponding curves for each load.

The residual indentation at the end of 24 hours was also measured on most of the floor coverings. The results were not appreciably different from those obtained at the end of 120 minutes.

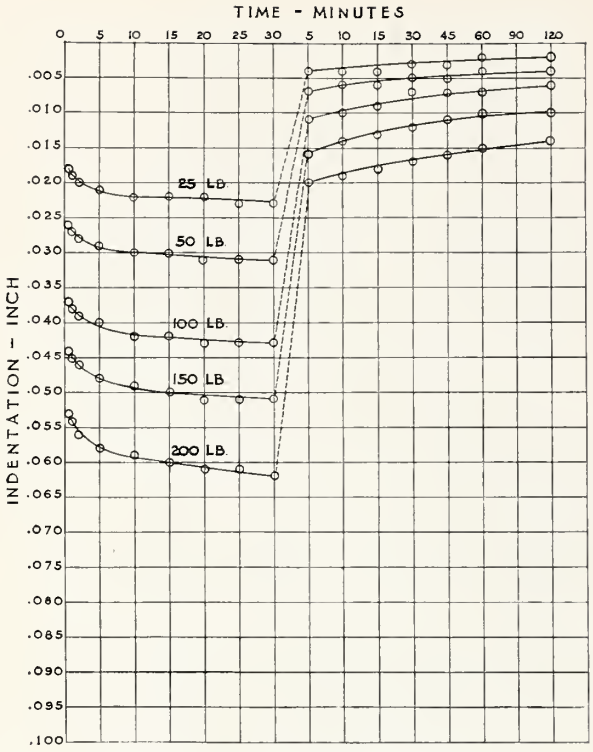

FIGURE 2.—*Brown battleship linoleum.*

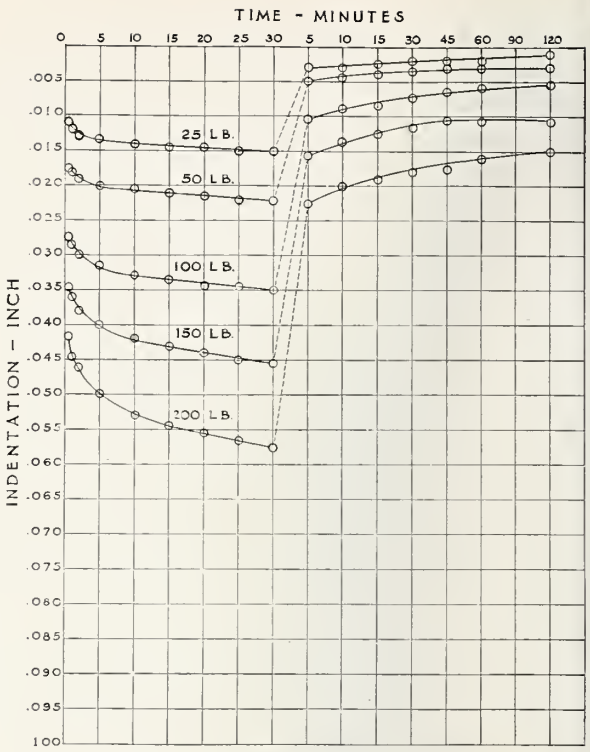

FIGURE 4.—*Green battleship linoleum.*

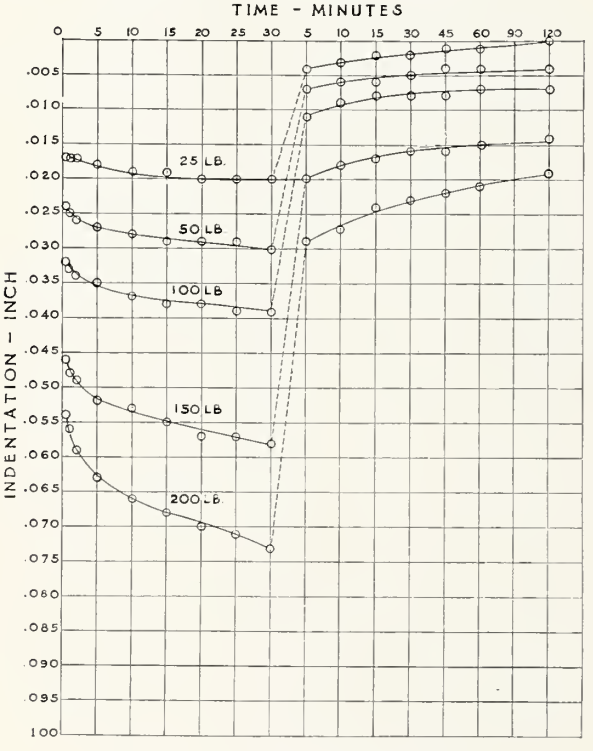

FIGURE 3.—*Gray battleship linoleum.*

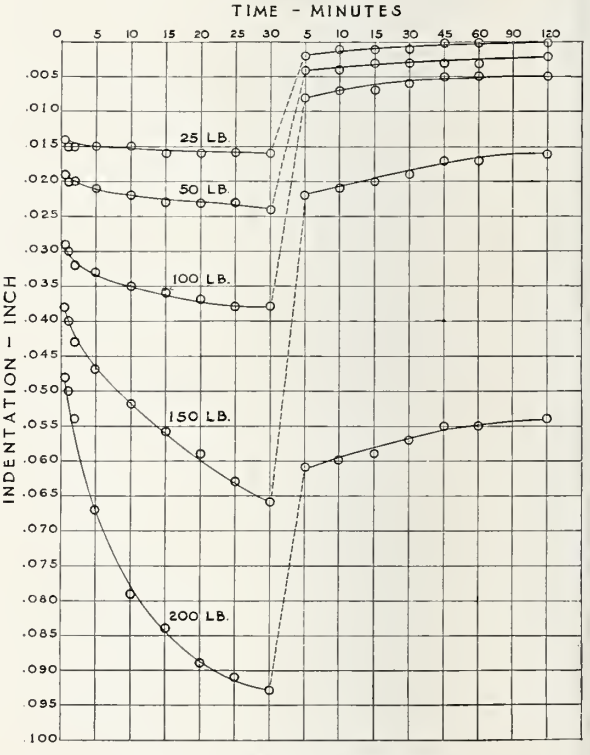

FIGURE 5.—*Marbleized linoleum.*

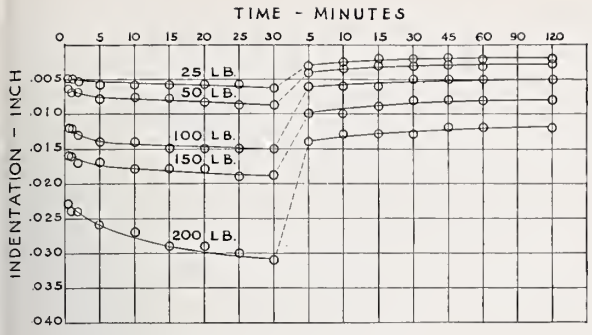

FIGURE 6.—*Inlaid linoleum.*

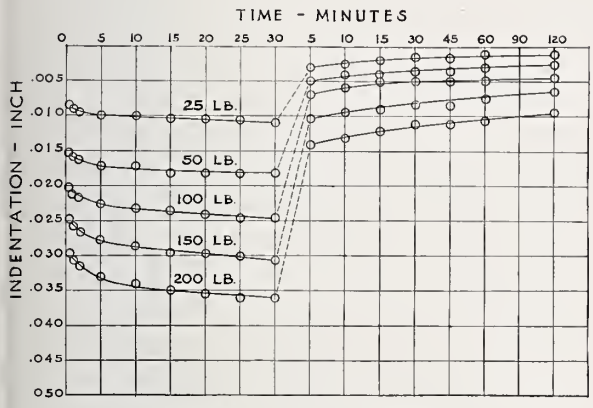

FIGURE 7.—*Jaspe linoleum.*

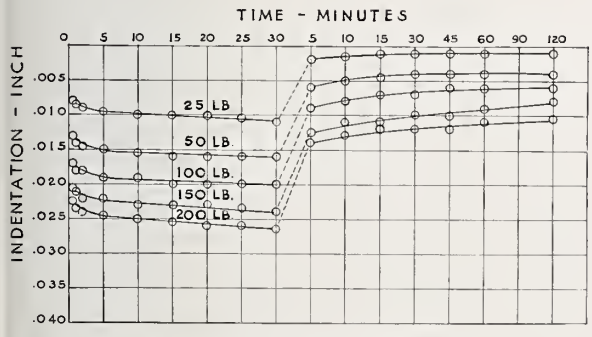

FIGURE 8.—*Printed linoleum.*

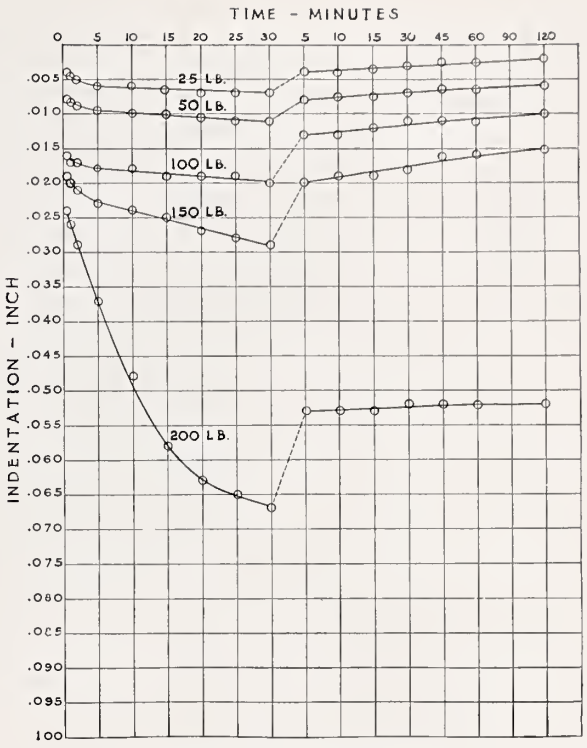

FIGURE 9.—*Inlaid felt base.*

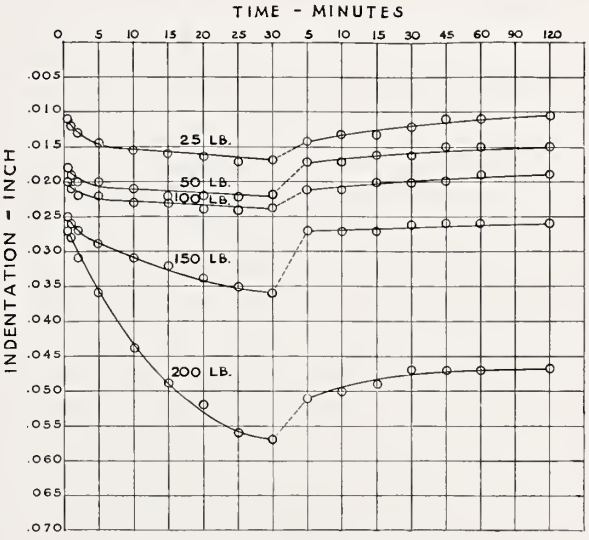

FIGURE 10.—*Printed felt base.*

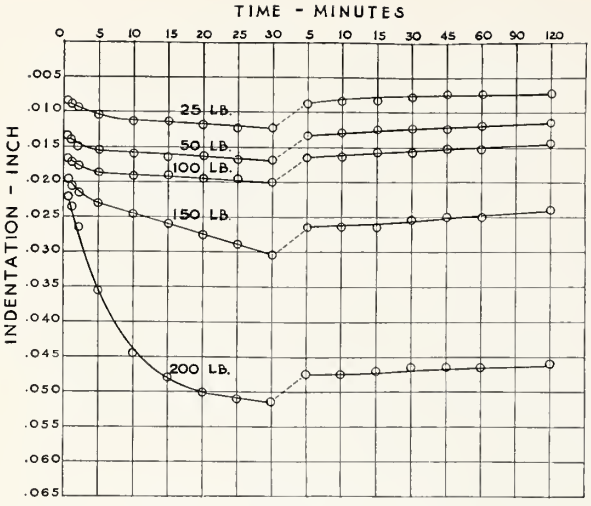

FIGURE 11.—*Printed felt base.*

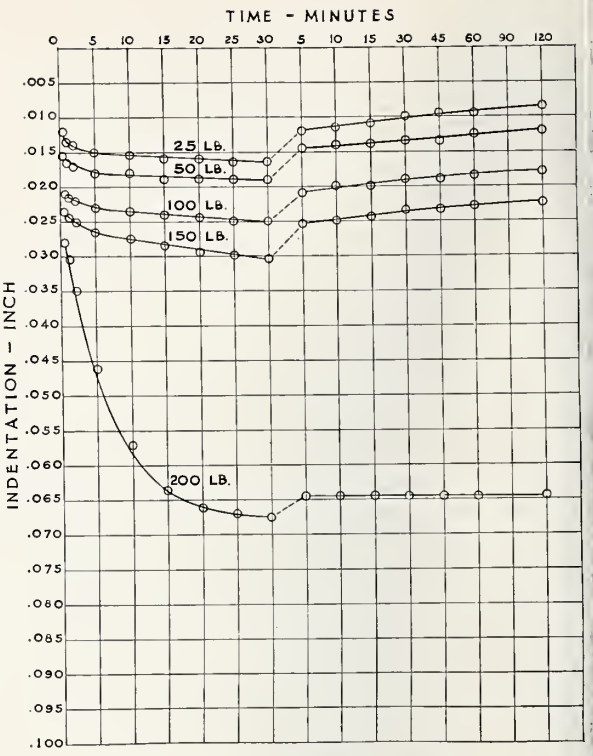

FIGURE 13.—*Composition felt base.*

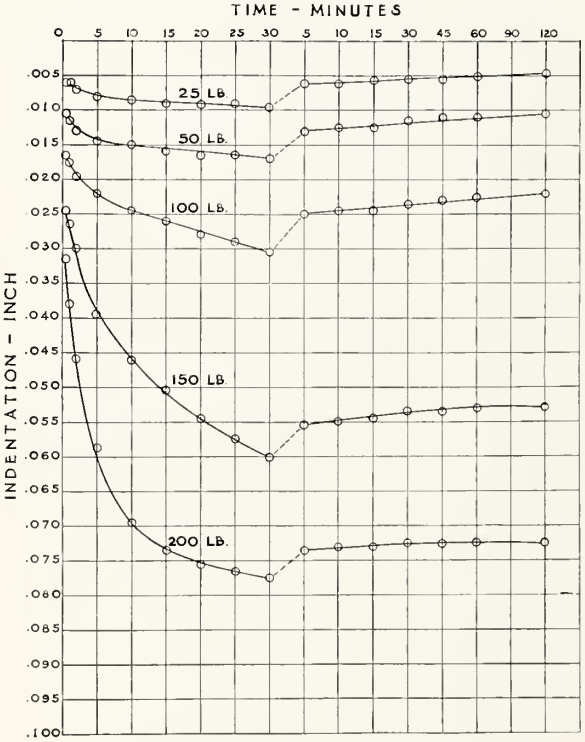

FIGURE 12.—*Mastic felt base.*

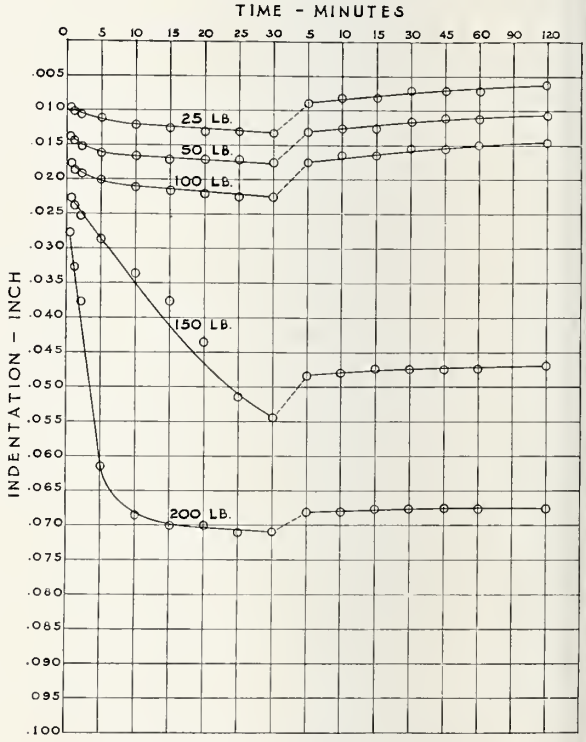

FIGURE 14.—*Composition felt base.*

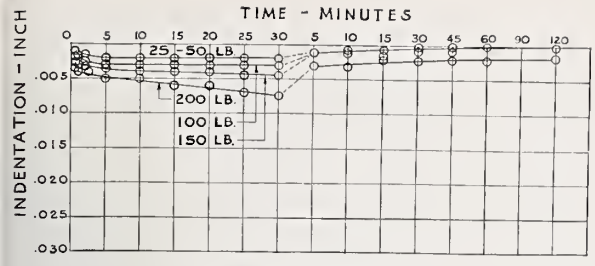

FIGURE 15.—*Asphalt tile.*

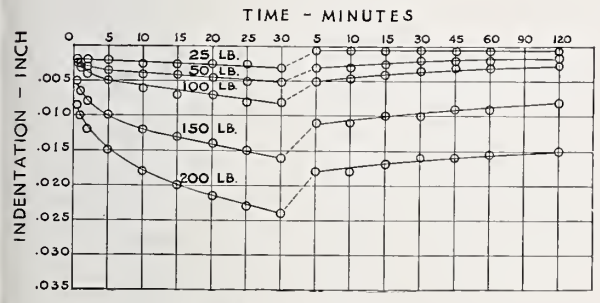

FIGURE 16.—*Asphalt tile.*

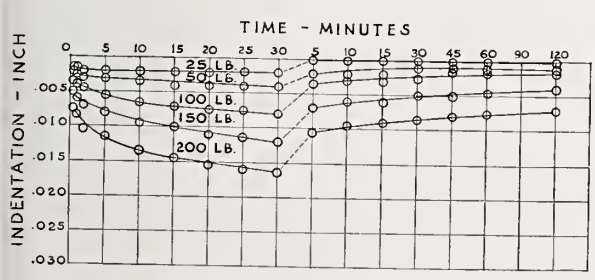

FIGURE 17.—*Asphalt tile.*

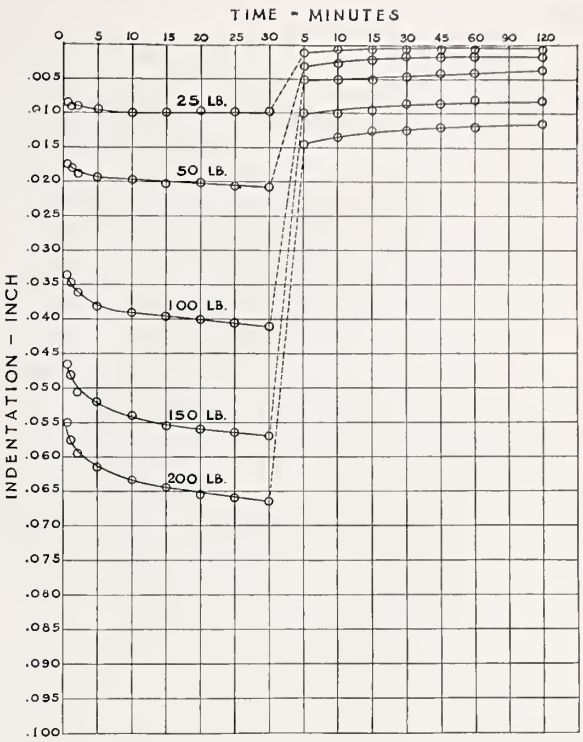

FIGURE 18.—*Sheet rubber.*

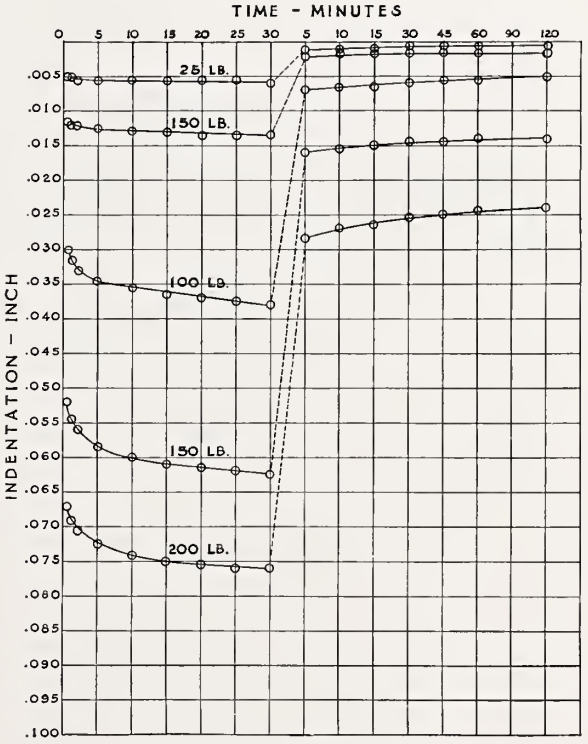

FIGURE 19.—*Rubber tile.*

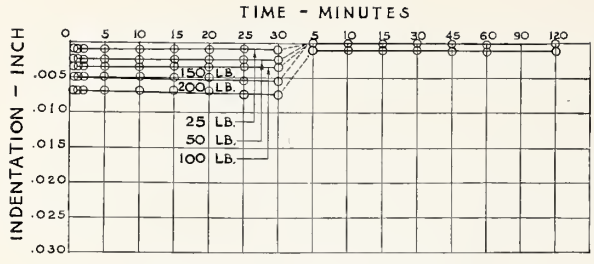

FIGURE 20.—*Pressed fiber board.*

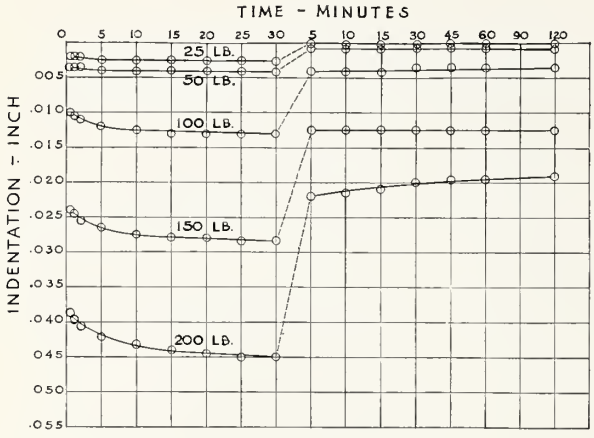

FIGURE 21.—*Strip yellow pine.*

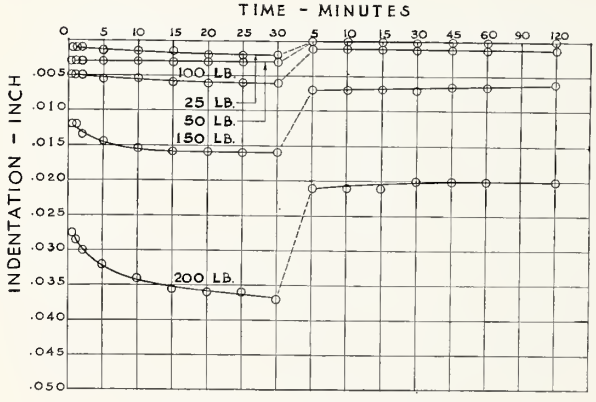

FIGURE 22.—*Strip Douglas fir.*

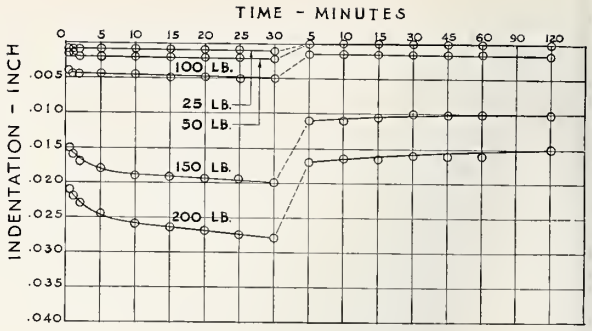

FIGURE 23.—*Strip white oak.*

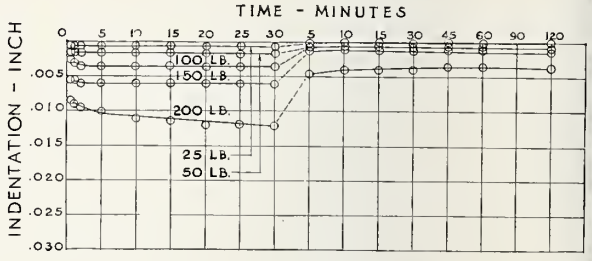

FIGURE 24.—*Short strip maple.*

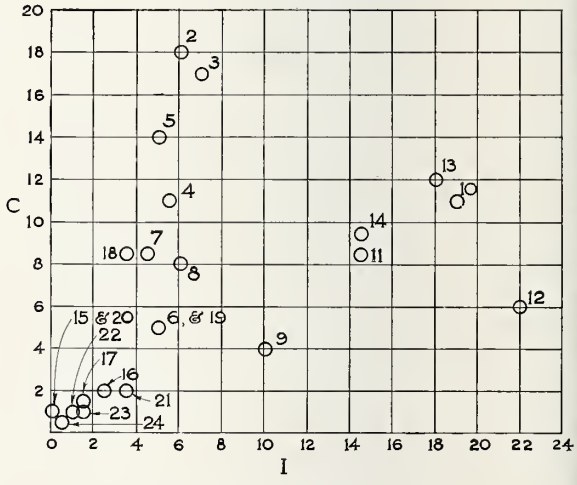

FIGURE 25.—*Summary of results.*

C, initial indentation for load of 25 pounds, mils. (An approximate measure of the relative comfort value.) *I*, residual indentation 120 minutes after removal of load of 100 pounds, mils. (An approximate measure of the extent to which the surface is permanently indented under abuse.)

VI. SUMMARY AND CONCLUSIONS

Figure 25 represents a summary of the results, which, with due consideration of price and other properties, should aid the consumer in selecting a floor covering. The numbers in the chart correspond to the sample numbers in table 1. The quantity C, which is used as an approximate measure of the relative comfort value, is the initial indentation (30 seconds after application of the load) for a load of 25 lb on the indenting tool. This load gives an average pressure of 509 lb/in.^{2} on the covering. The quantity I, which is used as an approximate measure of the extent to which the surface is permanently indented under abuse, is the residual indentation 120 minutes after the removal of a load of 100 pounds which has been applied for 30 minutes. This load gives an average pressure of 2,038 lb/in.^{2}

These pressures may seem quite high, but it can readily be demonstrated that such pressures may be attained under particles of gravel on which a person is standing, under the edge of a chair leg which is not squarely on the floor, or possibly under the edge of the heel when contact is first made with the floor in walking. Corresponding charts for either lower or higher loads can be prepared from the data shown in figures 2 to 24. If the quantity I were taken as the residual indentation 120 minutes after the removal of a load of 200 lb which has been applied for 30 minutes, representing very severe abuse, the relative performance of the several coverings would be roughly the same except for samples 5 and 9, which gave large residual indentations following a load of 200 lb but did not under a load of 100 lb. Pressures around 3,000 lb/in.^{2} appear to be critical for many of the floor coverings.

In the selection of a floor covering, the nature of the exposure to which it will be subjected, the desires of the occupant as to appearance and comfort, and the price are of importance. In general, so far as comfort and resistance to abuse are concerned, the coverings which are nearest the upper left-hand corner of figure 25 are most desirable. If resistance to abuse alone is considered, those farthest to the left are to be preferred; whereas, if comfort alone is considered, those nearest the top are the best. It must not be concluded, however, that the group of coverings to the right are not to be considered, because it is probable that the cost of this group is the lowest.

It should be noted that this report deals only with the particular samples tested and their relative performance with regard to indentation characteristics without consideration of other properties, such as abrasive wear, effect of moisture and temperature, effect of aging, adherence to subfloor, etc.

Indentation and recovery determinations are in progress on specimens of floor coverings listed in table 1 after exposure to heat and light to determine the effect of accelerated aging on indentation and recovery. Tests are also in progress to determine the effect of elevated temperature.

Washington, October 12, 1938.

The *National Bureau of Standards* was established by act of Congress, approved March 3, 1901, continuing the duties of the old Office of Standard Weights and Measures of the United States Coast and Geodetic Survey. In addition, new scientific functions were assigned to the new Bureau. Originally under the Treasury Department, the Bureau was transferred in 1903 to the Department of Commerce and Labor (now the United States Department of Commerce). It is charged with the development, construction, custody, and maintenance of reference and working standards, and their intercomparison, improvement, and application in science, engineering, industry, and commerce.

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Chemistry
- Paints, Varnishes, and Bituminous Materials
- Detergents, Cements, Corrosion, Etc.

Chemistry—Continued
- Organic Chemistry
- Metal and Ore Analysis, and Standard Samples
- Reagents and Platinum Metals
- Electrochemistry (Plating)
- Gas Chemistry
- Physical Chemistry
- Thermochemistry and Constitution of Petroleum

Mechanics and Sound
- Engineering Instruments and Mechanical Appliances
- Sound
- Aeronautic Instruments
- Aerodynamics
- Engineering Mechanics
- Hydraulics

Organic and Fibrous Materials
- Rubber
- Textiles
- Paper
- Leather
- Testing and Specifications
- Fiber Structure
- Organic Plastics

Metallurgy
- Optical Metallurgy
- Thermal Metallurgy
- Mechanical Metallurgy
- Chemical Metallurgy
- Experimental Foundry

Clay and Silicate Products
- Whiteware
- Glass
- Refractories
- Enameled Metals
- Heavy Clay Products
- Cement and Concreting Materials
- Masonry Construction
- Lime and Gypsum
- Stone

Simplified Practice
- Wood, Textiles, and Paper
- Metal Products and Construction Materials

Simplified Practice—Continued
- Containers and Miscellaneous Products
- Materials Handling Equipment and Ceramics

Trade Standards
- Wood, Wood Products, Paper, Leather, and Rubber
- Metal Products
- Textiles
- Apparel
- Petroleum, Chemical, and Miscellaneous Products

Codes and Specifications
- Safety Codes
- Building Codes
- Building Practice and Specifications
- Producer Contacts and Certification
- Consumer Contacts and Labeling

Office
- Finance
- Personnel
- Purchase and Stores
- Property and Transportation
- Mail and Files
- Library
- Information
- Editorial

Shops
- Design and Drafting
- Instrument Shop
- Woodworking Shop
- Glassblowing Shop
- Shop Tools and Equipment
- Materials and Supplies

Operation of Plant
- Power Plant
- Electrical
- Piping
- Grounds
- Construction
- Guard
- Janitorial